Virtual National Laboratory for Heavy Ion Fusion

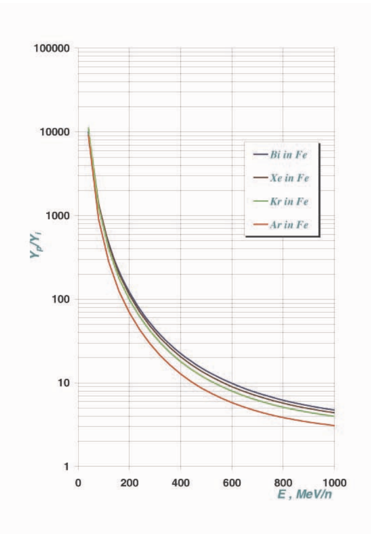
April 2002

HIF News

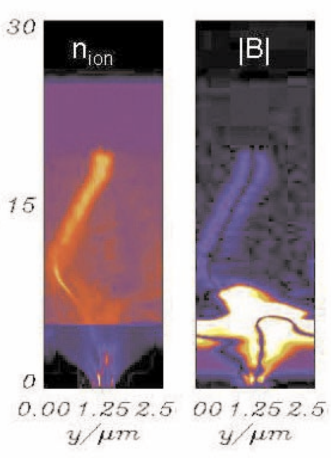
LBNL-PUB-844-02-04

Low neutron production predicted from lost ions in HIF driver

The neutron production from lost ions in an accelerator determines the necessary radiation protection shielding. An ion loss rate that allows hands-on-maintenance after a 4 hour cool-down in a 1 GeV proton machine is 1 W/m. HIF benefits from two factors: 1) the ions are heavy, and 2) their energy << 1 GeV/nucleon; both factors drastically reduce the ion penetration depth and consequently the number of the spallation reactions. Neutron yields for Bi, Xe, Kr, and Ar ions with energies 50-1000 MeV/nucleon were calculated using EPAX parameterization to estimate fragmentation cross-sections and the Bethe formula to calculate stopping power of the ions in the matter. Results shown are in agreement with measured neutron yields available in literature within a factor of 2. One concludes that tolerable losses for heavy ion accelerators at energies ≤50 MeV/nucleon (USA-HIF targets use ≤20 MeV/nucleon) can exceed Y_p/Y_i = 10,000 W/m; however such high losses are not economically attractive. In addition, the spectra of neutrons produced by ions in this energy range are much lower in energy than neutrons produced by 1 GeV protons, increasing the safety factor. We are encouraged by our calculation of low neutron yields and low neutron energies; however, further studies are necessary to determine the level of activation, which it is necessary to know for hands-on-maintenance. Theoretical and experimental studies of this are underway at GSI, Darmstadt in collaboration with ITEP, Moscow and GANIL, Caen. *– Edil Mustafin*



High current beam dynamics with laser accelerated ions



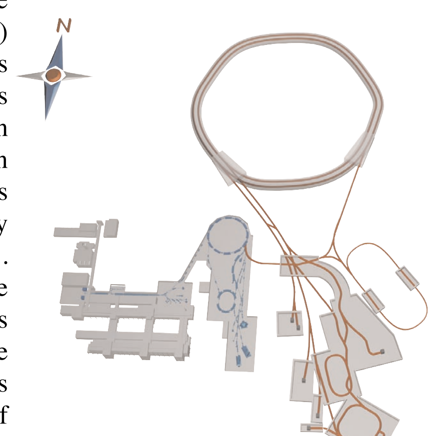
Certain aspects of HIF beam propagation, beam-target interactions and future driver design may be studied with available sources of laser-accelerated ions. Researchers from GA, GSI, LULI and MPQ have succeeded in producing ultra-low emittance, high-current neutralized proton and ion beams from ps (10^{-12} s) laser irradiation of thin foils at LULI's 50 TW laser facility. Ions are accelerated from the rear surface of a target foil by a virtual cathode set up by copious laser-generated few-MeV electrons from the front surface. The ps-duration, 10^{12} V/m electric field rapidly accelerates protons up to 25 MeV, which are charge neutralized in the expanding plasma. Proton currents of 10 kA, current densities of 10^{15} A/cm^2 and power densities of 10 TW/cm^2 (10^{13} W/cm^2) have been produced, with normalized transverse emittance at 10 MeV of $e_N<0.006\,\pi$ mm-mrad. Fluorine 7+ beams of up to 5 MeV/nucleon have been produced with 4% efficient coupling of laser energy to ions, and heavier ion beams are possible.

Researchers at GA and LBNL are using PIC simulations to evaluate HIF-relevant physics that may be addressed in a scaled fashion in future laser-ion experiments, such as: beam propagation in the fusion chamber environment, plasma formation and collective aspects of the ion beam stopping in foam absorbers. The figure illustrates the unstable transport of a 10 MeV proton beam penetrating a 10^{22} cm^{-3} plasma (left). The instability is due to self-generated magnetic fields at the interface (right). *– Tom Cowan and Hartmut Ruhl*

Proposal for a Major Upgrade of the GSI Heavy Ion Accelerator Facility

GSI (Gesellschaft für Schwerionenforschung), has proposed a major extension (shown in red) of its heavy ion accelerator facility to the German Scientific Council. A conceptual design report (CDR) describes the technical concept of the new superconducting, two-stage, heavy-ion synchrotrons (SIS100/200) and of the three storage rings (CR/NESR/HESR), to achieve a significant step forward in primary and secondary beam intensity and beam quality. It will use existing facilities as drivers, the UNILAC and the SIS18, shown in blue. The SIS200 will be dedicated to higher beam energies and longer extraction times, while the SIS100 will be optimised for the generation of short bunches of up to 2 x 10^{12} U-ions in an energy range from 400 to 2715 MeV/nucleon.

An area of emphasis, high-energy-density in matter, will use single bunches of ions, with durations of 25-90 ns, from the 1.3 MV rf bunch compressor system which is planned to be installed in SIS100. For this, acceleration of ions with intermediate charge states (e.g. U^{28}) maximises the number of ions in the new rings, but is challenging. Larger ionisation cross sections result in lifetimes roughly 100 times smaller than for highly stripped ions (e.g. U^{73+}). Significant changes in the "dynamic" vacuum, due to gas desorption processes from the beam pipe walls or inserts could lead to an avalanching of beam losses.



For the next milestone, the technical design report, we are pursuing design studies, technical planning, and technical developments with collaborators around the world. *-Peter Spiller*

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This work was performed under the auspices of the U.S. Department of Energy by the University of California Lawrence Livermore National Laboratory under contract No. W-7405-ENG-48 and by Lawrence Berkeley National Laboratory under contract No. DE-AC03-76SF00098 (LBNL), and by Princeton Plasma Physics Laboratory performed under the auspices of the U.S. Department of Energy under contract No.DE-AC02-76CH-O3073.